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FRUITS:

Consumer Quality Characteristics, Yield, and Preparation Time of Various Market Forms



Home Economics Research Report No. 29

**Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE**

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Human Nutrition Research Division

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FRUITS: Consumer Quality Characteristics, Yield, and Preparation Time of Various Market Forms

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SUMMARY

Preparation time requirements, yield, and quality were determined on fresh, canned, and frozen fruits—grapefruit, orange juice concentrate, peaches, pineapple, raspberries, and strawberries. Also, preparation time and yield were determined on six additional fruits in various market forms: Apples, cherries, cranberries, lemons, plums, and rhubarb.

Steps in the preparation of the fruits were recorded in two categories: (1) Active preparation time, which includes activities requiring the full attention of the homemaker, and (2) total preparation time, which includes time for active preparation and other time—as for thawing or baking—that does not require the full attention of the homemaker.

Fresh fruits required the most time for active preparation. However, total preparation time was longest for frozen fruits. Canned fruits required very little time for preparation. Active preparation time for fresh fruits ranged from 1 minute for Bing cherries served unpitted, to more than 38 minutes for red sour cherries served pitted. Total preparation time for canned fruits was from one-quarter minute, the time required for opening the can, to more than 10 minutes for fruits requiring heating. For frozen fruits, total time ranged from 2½ minutes for lemonade and orange juice concentrates to 180 minutes for baked apples.

In most cases, fresh fruits as purchased yielded higher percentages of drained solids than did the frozen or canned fruits. Yield of drained prepared fruit ranged from about 40 to 95 percent for the fresh fruits, 44 to 100 percent for frozen fruits, and 35 to 81 percent for canned fruits. The yield of drained solids for the majority of fresh fruits was above 80 percent.

Most of the fruits were near optimum in color, as shown by panel color scores and color-difference meter values. However, color scores for the fresh fruits were higher than for the canned or frozen fruits. Of the frozen fruits investigated grapefruit appeared to be most uniform in color'

as indicated by color-difference meter and panel color scores. The color of the frozen pineapple and orange juice was also generally good. Frozen peaches were variable in color because of brown spots on some samples. Frozen raspberries and strawberries had the greatest color variation because of their tendency to darken.

Highest flavor scores were usually given to the fresh fruits. Texture of most of the fresh fruits was near optimum. Texture of the frozen and canned fruits was good, in most cases, but these products were slightly softer than the fresh fruits.

For all frozen fruits, ascorbic acid content of both solids and liquids varied considerably. Raspberries, with a range in ascorbic acid content of 0.8 to 23 milligrams per 100 grams of solids and a coefficient of variation of 38, were most variable. In grapefruit, most of the ascorbic acid was in the reduced form; the ratio of oxidized to reduced ascorbic acid was only 0.11, indicating stability of ascorbic acid in this fruit. For the other fruits, the ratios ranged from 0.51 in pineapple to 0.71 for raspberries.

Wide variations were found in ratios of ascorbic acid in solids to ascorbic acid in liquids of frozen fruits. Except for raspberries, the majority of the ratios were in the range 0.50 to 1.25. Ratios appeared to be characteristically higher for raspberries than for the other fruits investigated.

Ratios of titratable acidity in solids to titratable acidity in liquids of frozen fruits were, except for grapefruit, similar to ascorbic acid ratios. The titratable acid ratio for grapefruit was considerably higher than its ascorbic acid ratio. In general, diffusion of acid from solids to liquids would be associated with storage at temperatures above 0° F. The amount of diffusion, however, would be characteristic of the fruit investigated.

Ratios of soluble solids in solids to soluble solids in liquids of frozen fruit were quite variable. A low ratio would indicate good storage conditions before purchase. Lowest ratios were found for raspberries and peaches. The highest ratio, 0.78, was for pineapple.

The cloud determinations carried out on orange juice concentrate indicated that none of the samples had been previously thawed and refrozen.

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PURPOSE OF THE INVESTIGATION

The widespread use of convenience foods has created interest in the comparative quality, yield, and time required for kitchen preparation of fresh, canned, and frozen fruits and vegetables. Although canned fruits are still most widely used (14),² other types of convenience foods have made rapid gains. More than 704 million pounds of frozen fruits, excluding citrus products, were packed in 1961 (19). Information regarding the quality of frozen fruits on the retail market is therefore timely.

Extensive investigations of the quality of frozen fruits obtained directly from a processor have been reported by the Western Utilization Research and Development Division of the Agricultural Research Service (8, 9, 15) and by the Wisconsin Alumni Research Foundation (3, 5).

Relatively little research has been reported, however, on the quality of frozen fruit from retail market channels. Kelsey has pointed out that high temperature during transportation and stor-

age has an adverse effect on quality of frozen food in retail stores (10). Surveys conducted by Morin (17), Dykstra (6), and Munter and others (18) indicated mishandling of frozen foods in retail stores. Lamden and others (13) found that the ascorbic acid content of chilled orange juice purchased in the Burlington, Vt., area was considerably lower than that of fresh orange juice.

Research on relative costs in time and money involved in the purchase and use of different foods in different stages of preparation has been carried out by Iowa State University in cooperation with the Federal Extension Service, U.S. Department of Agriculture (11).

The present study was carried out in cooperation with the Marketing Economics Division, Economic Research Service, to obtain data on preparation-time requirements, yield in servings, and product quality of a variety of foods in different market forms. Information on vegetables has been reported (23). Research was conducted by the Economic Research Service on companion projects to determine the effects of processing for consumer convenience on retail food prices.

² Italic numbers in parentheses refer to Literature Cited, p. 28.

SCOPE OF THE WORK

Fruits widely available in various market forms on the retail market were included in the study.

Fresh fruits investigated were dark sweet cherries, red sour cherries, cranberries, grapefruit, lemons, oranges, peaches, pineapple, plums, red raspberries, rhubarb, and strawberries.

Canned fruits selected for study included baked apples, dark sweet cherries, red sour cherries, cherry sauce, strained and whole cranberry sauces, grapefruit sections, lemon juice, orange juice, peach halves, pineapple chunks and slices, plums, red raspberries, whole strawberries, and strawberry pie filling.

Because of the scarcity of information regarding the quality of frozen fruits available to the ultimate consumer, a considerable portion of the study was directed to an investigation of frozen fruits.

Six frozen fruits were selected for detailed quality evaluation because they are among those packed in the largest quantity (19). These fruits were grapefruit, orange juice concentrate, sliced peaches, pineapple chunks, red raspberries, and

strawberries. Four additional frozen fruits—baked apples, red sour cherries, lemonade concentrate, and rhubarb—were used in a more limited study.

Preparation time and yield were determined on fresh, canned, and frozen fruits. Preparation time included time spent in preparation by commonly used household methods, as well as cooking time for those fruits that required cooking.

On most samples of fresh, canned, and frozen fruits, quality evaluations included reflected color measurements, shear-force readings, and panel scores for color, texture, and flavor.

Additional quality evaluation tests carried out on five of the six frozen fruits (orange juice excluded) and on the juice fractions of the frozen fruits were: Reduced ascorbic acid, dehydroascorbic acid plus diketogulonic acid, soluble solids, and titratable acidity. On orange juice concentrate, determinations were made of thawing index (TI), sensitivity index (SI), and reduced and oxidized ascorbic acid.

EXPERIMENTAL PROCEDURES

Purchase and Storage of Fruits

All fresh, canned, and frozen fruits were purchased from retail markets in the Washington, D.C., metropolitan area during the years 1960 and 1961.

Fresh fruits were purchased the day before testing, at the peak of the season for each fruit. They were stored in a walk-in refrigerator at 42° F. until used.

Canned fruits were stored from one to two weeks at 72° F. before use. When available, two brands of each fruit were purchased.

Frozen fruits were transported to the laboratory in insulated bags and stored at -8° to -12° F. until used, no longer than one week. For separate study, six frozen fruits were purchased in each of four seasons from three stores under different managements and having high volume sales in the locality. The fruits included were four brands of orange juice; three brands each of peaches, raspberries, and strawberries; and one brand each of grapefruit and pineapple. The sampling plan for the stores and brands of frozen fruits used in this experiment is shown in table 1. Three or four samples, one for each brand-store combination of a single fruit, were studied per day. Each combination was replicated four times each season for four consecutive seasons, beginning with the spring season.

The sampling of fresh, canned, and frozen fruits was carried out according to a randomized design, Cochran and Cox (4), which specified the order of testing.

TABLE 1.—*Plan for selecting samples of fruit*

Fruit	Brands purchased from—			
	Store 1	Store 2	Store 3	Store 4
Peaches and raspberries	A	B	C	-----
Strawberries	A	-----	C	B
Orange juice concentrate	A	D E	C	-----
Grapefruit sections	F	F	F	-----
Pineapple chunks	-----	G	G	G

Preparation of Samples

Preparation time.—The time required for each step in preparing the fruits was recorded in two categories: (1) Active preparation time, and (2) total preparation time. Active preparation time is the time spent in activities requiring the full attention of the homemaker—such as washing, paring, trimming, and cutting—and the time for water to come to a boil before adding the fruit. Total preparation time includes time for active preparation and all other preparation—such as thawing and cooking processes—that does not require the full attention of the homemaker.

The procedures used in preparing each of the fruits are given in table 2.

Frozen fruits were defrosted on a wire rack in the draft of a fan in a room held at a temperature of 72° F. Orange juice concentrate was defrosted for 15 minutes before reconstituting; other fruits were defrosted for 75 minutes for chemical tests and 90 minutes for other tests.

Samples to be used for chemical determinations were removed from the freezer one package at a time. After defrosting, samples were weighed and then drained for 5 minutes in a colander. Weights of solids and liquids and other pertinent data such as lot numbers and brown spots for peaches were recorded.

For shear and color-difference meter readings, two packages of each sample were drained for 5 minutes and readings taken on the solids only.

For orange juice, one can per sample was used for both palatability and color-difference meter evaluations and one can for ascorbic acid and cloud determinations. For the other fruits, two additional packages were mixed and used for panel evaluations of color, texture, and flavor.

Cooking methods.—Accepted household methods were used for those fruits that were cooked (table 2). Amounts of sugar added to the fruits are given in table 3.

Quality Evaluation

Yield.—For canned and frozen fruits, yield data including the net weight as given on the container were recorded.

All foods were weighed in grams, and weights were converted to ounces for ease in comparing package weights, which are usually expressed in ounces and pounds.

For fresh fruits, yield data included weight and description of inedible portions trimmed from the fruits before washing, and weight of trimmed fruit after washing.

For the canned fruits, weight and volume of the total contents of the can and of the drained solids and liquids were determined. When available, two different brands of each of the canned fruits and at least two cans of each brand were used for compiling yield data.

For the frozen fruits, package contents were weighed and the weight and volume of the drained fruits were determined. One, and in some cases, two brands of frozen fruit were completely defrosted at room temperature, to obtain yield on solids and liquids separately.

Fruits with liquid present as purchased or as prepared were drained for 1 minute before determining weights of solids and of liquids. If no liquid was present after preparation, the yields are reported as yield of drained solids. If liquids and solids were inseparable, or, if only liquid was present, as in orange juice, yields are reported as combined yield of solids and liquids.

The number of servings per purchase unit was calculated on the basis of equal weight servings in different market forms of the same fruit. If the weights of specified individual servings (usually one-half cup) were not the same for all forms of the fruit, the weight of the form with the greatest number of samples was selected for use in calculations. This figure was divided into

TABLE 2.—*Procedure for preparing fresh, canned, and frozen fruits*

Fruit and preparation form	Preparation steps for—		
	Fresh fruit	Canned fruit	Frozen fruit
Apples, baked.....		Open container.....	Thaw; open container.
Cherries, dark sweet:			
Served unpitted.....	Wash.....	do.....	
Served pitted.....	Wash, stem, and pit.....	Open container; drain; pit.....	
Cherries, red sour:			
Served uncooked.....	Wash, sort, and stem; pit.....	Open container.....	Do.
Served cooked.....		Measure ingredients; bring sugar and water to a boil; add cherries and return to a boil; boil 5 minutes.	
Cherry sauce.....		Open container.....	
Cranberry sauce:			
Served whole.....	Open package; wash and sort berries; measure ingredients; bring sugar and water to a boil; add berries and return to a boil; boil 15 minutes.	do.....	
Served strained.....	Same as above, and strain.....		
Grapefruit.....	Wash and dry; pare; remove sections and juice from membranous core.	Open container.....	Do.
Lemons.....	Wash and dry; cut in half; extract juice with a hand-operated lever-type juicer; strain.	Bottle: Open container. Plastic lemon: Extract juice.	Open container; reconstitute.
Oranges.....	Home-squeezed: Wash and dry; cut in half; extract juice with hand-operated lever-type juicer. Store-squeezed: Open container.	Open container.....	Do.
Peaches:			
Served peeled, whole.....	Wash and dry; peel.....	Open container.....	Thaw; open container.
Served sliced.....	Same as above; slice and remove pits.		
Pineapple.....	Remove crown; pare and core; cut in chunks.	Open container.....	Do.
Plums:			
Served whole, raw or cooked.	Wash and dry; remove stems.	do.....	
Served as halves, raw.....	Same as above; cut in half; remove pits.		
Served whole or as halves, cooked.	Wash and dry; remove stems. Measure ingredients; bring sugar and water to a boil; add plums (whole or halves) and return to a boil; boil 5 minutes.		
Raspberries, red.....	Sort and hull; wash.....	Open container.....	Do.
Rhubarb.....	Wash; trim; slice; measure ingredients; bring sugar and water to a boil; add rhubarb and cook 5 minutes.		Thaw; open container; measure ingredients; bring sugar and water to a boil; add rhubarb and return to a boil; boil 6½ minutes.
Strawberries.....	Wash; sort and hull; trim.....	Open container.....	Thaw; open container.
Strawberry pie filling.....		do.....	

the weight of the total drained food to determine the number of servings per purchase unit. Where ½-cup servings of fresh, canned, and frozen fruits were unequal in weight, the calculated volume of equal weight servings was reported.

Reduced ascorbic acid.—Reduced ascorbic acid was determined in peaches, orange juice, pine-

apple, and grapefruit by the indophenol procedure of Bessey and King (2). Formaldehyde was used to correct for reductones, as proposed by Mapson (16), and hydrogen peroxide, as suggested by Robinson and Stotz (20), to correct for sulfites, iron, and tin. Strawberries and raspberries, because of their intense red color, were most

TABLE 3.—*Sugar added to cooked fruits*

Fruit and preparation form	Market form	Market unit	Sugar added
Cherries, red sour, cooked.....	Canned, water pack.....	No. 303 can.....	Cup 0.3
Cranberry sauce, whole or strained.....	Fresh.....	1-lb. package.....	2.0
Plums, cooked whole or halves, unpeeled.....	do.....	1-lb. bulk.....	.7
Rhubarb.....	{ Fresh.....	1-lb. bulk.....	.3
	{ Frozen.....	1-lb. package.....	.3

readily analyzed for ascorbic acid by the photometric xylene extraction method of Robinson and Stotz (20).

Dehydroascorbic acid plus diketogulonic acid.—Determination of these products was made by a modification of the procedure of Roe (21, 22) using 2,4-dinitrophenylhydrazine.

Titrateable acidity.—Titrateable acidity was determined on solids and juices of all fruits except orange juice. Solids were blended with water; liquids were diluted with water. Both were diluted to volume and aliquots titrated to pH 8 with 0.1N NaOH, as described by Guadagni and others (8).

Reflected color.—Gardner Color-Difference Meter (7) readings were taken, using the “*L*” scale in which *L* expresses visual lightness; *a_L*, redness or greenness; and *b_L*, yellowness or blueness. Five readings were taken; between readings the sample was turned about 72°. The average of the five measurements was considered the color value of the sample. The color standards used for the fruits tested are shown in table 4.

Shear force.—An L.E.E. Kramer Shear Press (12) with a standard cell and a 1,000-pound proving ring was used for all fruits tested except pineapple, which required a 3,000-pound proving ring.

Soluble solids.—Determinations of soluble solids were made with a Bausch & Lomb Abbe —3-L Refractometer (1).

Cloud.—Cloud determinations were made on orange juice reconstituted to 5° Baumé. Both the thawing index (TI) and the sensitivity index

TABLE 4.—*Color standards for fruits tested*

Fruit	<i>L</i> (visual lightness)	<i>a_L</i> (redness or greenness)	<i>b_L</i> (yellow- ness or blueness)
Orange juice.....	74.6	+2.7	+50.5
Strawberries, rasp- berries.....	24.6	+18.3	+5.6
Peaches.....	51.8	—3.4	+30.2
Grapefruit, pineapple.....	78.2	—1.7	+22.6

(SI) were determined by the procedure of McColloch and Rice (15).

Panel evaluation.—Color, flavor, and texture of the fresh, canned, and frozen fruits were rated by a trained panel of five members. Consistency of juice was also rated for peaches, raspberries, and strawberries. Coded samples were presented to the panel for quality ratings and for detection of any off-flavor.

The fresh and canned fruits were rated as follows: Color ranged from 5, very good, to 1, very poor; texture ranged from 5, characteristic, to 1, very poor; flavor ranged from 5, very desirable, to 1, very undesirable. The rating scales for each quality characteristic of the various frozen fruits are given in table 5. Scores given in the text refer to mean values for all members of the panel.

Evaluation of data.—Mean values, ranges, and coefficients of variation were calculated on data for all quality characteristics of the frozen fruit samples investigated.

TABLE 5.—FROZEN FRUITS: *Rating scales for palatability evaluation*

Fruit	Rating scale for—			
	Color	Flavor	Texture	Consistency of juice
Grapefruit sections.	5—Bright, lustrous, natural. 4—Slightly dull. 3—Moderately dull. 2—Very dull, slightly dark. 1—Dark and off-colored.	5—No off-flavor. 4—Slight off-flavor. 3—Moderate off-flavor. 2—Strong off-flavor. 1—Very strong off-flavor.	9—Very tough. 8—Moderately tough. 7—Slightly tough. 6—Slightly too firm. 5—Tender, yet firm. 4—Slightly too tender. 3—Moderately soft. 2—Very soft. 1—Mushy.	
Orange juice concentrate.	5—Bright, lustrous, natural. 4—Slightly less bright and lustrous than 5. 3—Slightly dull or muddy. 2—Moderately dull or muddy. 1—Very dull or very muddy.	5—No off-flavor. 4—Slight off-flavor. 3—Moderate off-flavor. 2—Strong off-flavor. 1—Very strong off-flavor.	5—Uniform distribution of liquid and solids; no separation. 4—Slight separation of liquid and solids. 3—Moderate separation of liquid and solids. 2—Much separation of liquid and solids. 1—Almost complete separation of liquid and solids.	
Peaches, sliced...	5—Natural, bright. 4—Slightly dull. 3—Slightly brown. 2—Moderately brown. 1—Very brown.	5—No off-flavor. 4—Slight off-flavor. 3—Moderate off-flavor. 2—Strong off-flavor. 1—Very strong off-flavor.	9—Very hard or very tough. 8—Moderately hard or moderately tough. 7—Slightly hard or slightly tough. 6—Slightly too firm. 5—Firm, tender; no sloughing. 4—Slight sloughing. 3—Some cell collapse, moderate sloughing. 2—Some mushiness. 1—Very soft, mushy.	5—Clear, no cloudiness. 4—Slight cloudiness. 3—Moderate cloudiness. 2—Very cloudy. 1—Juice thick with pulp.
Pineapple chunks.	5—Bright, lustrous, natural, uniform. 4—Slightly dull, slightly streaked or spotted. 3—Moderately dull, moderately streaked or spotted. 2—Very dull, slightly dark, very streaked or spotted. 1—Dark and off-colored, extremely streaked or spotted.	5—No off-flavor. 4—Slight off-flavor. 3—Moderate off-flavor. 2—Strong off-flavor. 1—Very strong off-flavor.	9—Very tough. 8—Moderately tough. 7—Slightly tough. 6—Slightly too firm. 5—Tender, yet firm. 4—Slightly too tender. 3—Moderately soft. 2—Very soft. 1—Mushy.	
Raspberries and strawberries.	5—Bright, natural red. 4—Slightly less bright red than 5. 3—Slightly dull, slightly dark, or slightly faded. 2—Moderately dull, moderately dark, or moderately faded. 1—Extremely dull, faded or dark.	5—No off-flavor. 4—Slight off-flavor. 3—Moderate off-flavor. 2—Strong off-flavor. 1—Very strong off-flavor.	9—Very hard or very tough. 8—Moderately hard or moderately tough. 7—Slightly hard or slightly tough. 6—Slightly too firm. 5—Firm, tender, no sloughing. 4—Slight sloughing. 3—Some cell collapse, moderate sloughing. 2—Some mushiness. 1—Very soft, mushy.	5—Clear, no cloudiness. 4—Slight cloudiness. 3—Moderate cloudiness. 2—Very cloudy. 1—Juice thick with pulp.

RESULTS AND DISCUSSION

Fresh Fruits

Preparation time.—Preparation times for fresh fruits are given in table 6. Active preparation time for approximately 1 pound as purchased ranged from 1 minute for unpitted Bing cherries to over 38 minutes for pitted red sour cherries. Most of the fruits required full attention (active time) throughout the total preparation time.

Three fruits—cranberry sauce, plums, and rhubarb—required additional preparation time (heating) that did not require the full attention of the worker.

Yield.—In table 7, data are given on the yield of fresh fruits purchased from retail markets in the Washington, D.C., area. The ranges in weight per market unit of fruits were generally quite small, except for pineapple and home-squeezed orange juice. The discarded portions of the fresh fruits caused the yields to be less than the corresponding values for the frozen fruits. Parts discarded ranged from 0.4 percent by weight for cranberry sauce to 56 percent for home-squeezed lemon juice.

Yield of solids plus liquids covered a wide range, from about 43 percent for home-squeezed lemon juice to an increase to 239 percent for whole cranberry sauce. The addition of ingredients to some of the fruits was, of course, a factor in the percentage yields.

Yield of drained solids ranged from about 40 percent for grapefruit to 95 percent for raw plums and raspberries.

Number of servings per pound for solids plus liquids ranged from 1.7 for home-squeezed orange juice to 16 for whole cranberry sauce with its added ingredients. Most of the differences are due to amounts of ingredients added or parts discarded during preparation. Number of servings per pound for drained solids ranged from 1.9 for grapefruit to 5.8 for raspberries.

The amounts of fresh fruit as purchased that were required for one serving of solids plus liquids ranged from 1 ounce for whole cranberry sauce to 9.3 ounces for home-squeezed orange juice. As would be expected, there was very little similarity among fruits in this respect. Amounts of drained solids needed for one serving did not vary as widely as did those for solids plus liquids. The range was from 2.8 ounces for raspberries to 8.2 ounces for grapefruit, with most of the fruits requiring from 4 to 5 ounces per serving.

Color, texture, and flavor.—In the investigation on fresh fruits, the principal objective was to obtain data on preparation time and yield; however, the fruits were evaluated also for color, texture, and flavor.

Panel scores for color, texture, and flavor of fresh fruits generally ranged between 4.0 and 5.0,

TABLE 6.—FRESH FRUITS: *Preparation time for family-sized units*

Fruit and preparation form	Market unit		Preparation time ¹		Samples
	Container	Weight	Active	Total	
		Ounces	Minutes	Minutes	Number
Cherries, dark sweet (Bing), raw:					
Unpitted.....	Bulk.....	16.0	1	1	3
Pitted.....	do.....	16.0	16	16	3
Cherries, red sour, raw, pitted.....	Quart basket.....		38¾	38¾	4
Cranberries:					
Strained sauce.....	Cellophane package.....	16.0	15½	30½	4
Whole sauce.....	do.....	16.0	12	27	4
Grapefruit, raw, sections.....	1 grapefruit.....		8	8	6
Lemon juice, home-squeezed.....	1 lemon.....		1¼	1¼	12
Orange juice:					
Home-squeezed.....	1 doz. oranges.....		7¼	7¼	1
Store-squeezed.....	1-qt. bottle.....		¼	¼	2
Peaches:					
Raw, whole, peeled.....	Bulk.....	15.7	7½	7½	5
Raw, sliced.....	do.....	15.7	9¼	9¾	5
Pineapple, raw, chunks.....	1 pineapple.....		8¼	8¼	2
Plums:					
Raw, whole.....	Bulk.....	16.0	2¼	2¼	2
Raw, halves.....	do.....	16.0	4¾	4¾	2
Cooked whole, unpeeled.....	do.....	16.1	6½	11½	2
Cooked halves, unpeeled.....	do.....	16.0	14	19	2
Raspberries, red, raw.....	Pt. basket.....		7¼	7¼	6
Rhubarb, cooked, with liquid.....	Bulk.....	16.0	10	10	4
Strawberries, raw, whole.....	Qt. basket.....		11¼	11¼	16

¹ All fruits were allowed to drain 1 minute if liquid was present as purchased or as prepared, in addition to the time recorded above.

TABLE 7.—FRESH FRUITS: *Yield of prepared food as served and parts discarded from units purchased in bulk*

Fruit and preparation form ¹	Market unit	Weight of food per market unit ²		Parts discarded		Yield of prepared food as served		Servings					Sam- ples
		Mean	Range	Mean ³	Description	Mean ⁴	Range	Weight per serving	Approximate size	Servings per market unit	Servings per pound as purchased	Amount as purchased for 1 serving	
Cherries, dark sweet (Bing): Unpitted	Bulk	Ounces 16.0		Per- cent 3.5	Stems and spoiled cherries.	Per- cent	Percent	Ounces		Num- ber	Num- ber	Ounces	Num- ber
Drained solids	Bulk	16.0		11.4	Pits, stems, and spoiled cherries.	88.1	85.7-89.9	3.5	0.6 cup	4.3	4.3	3.7	7
Drained solids								3.5	.6 cup	4.0	4.0	4.0	7
Cherries, red sour: Unpitted ⁵	Qt. basket	22.2	20.0-23.3	18.0	Pits, stems, and spoiled cherries.	80.7	78.7-83.8	3.9	.7 cup	4.6	3.3	4.8	4
Drained solids													
Cranberries: Strained sauce	1-lb. cellophane package.	16.6	16.4-16.8	.4	Spoiled berries.								
Solids and liquid								2.4	.25 cup	12.6	12.1	1.3	3
Whole-berry sauce	Cellophane package.	16.6	16.4-16.8	.4	Spoiled berries.								
Solids and liquid								2.4	.25 cup	16.6	16.0	1.0	4
Grapefruit	Bulk, 1 grapefruit.	23.0	22.5-24.2	47.6	Rind, seeds, and membrane.								
Solids and liquid						49.4	45.4-53.2	4.3	.5 cup	2.7	1.9	8.5	18
Drained solids						40.8	26.7-45.2	3.4	.5 cup	2.8	1.9	8.2	18
Lemon juice, home-squeezed	Bulk, 1 lemon.	3.2		56.0	Rind, seeds, membrane, and pulp.								
Solids and liquid						43.4		1.1	2.0 tbsp	1.3	6.5	2.5	12

indicating near optimum quality (table 8). Exceptions were texture scores for whole cranberry sauce and cooked plums, 3.2, and flavor scores for strained cranberry sauce, 3.2.

The range in color-difference meter and shear-force values was small for individual lots of the various fruits investigated (tables 8 and 9). Dark sweet cherries were an exception, with values for a_L ranging from 2.6 to 10.2. No more than two samples were used for any of the evaluations.

Canned Fruits

Preparation time.—Preparation times for canned fruits are shown in table 10. Active preparation time for most fruits was one-quarter minute, the time required for opening the can and removing the contents. Bing cherries when pitted required the most time for active preparation—8 minutes.

Total preparation time ranged from one-quarter minute for those fruits served with liquid to over 9 minutes for red sour cherries cooked with sugar.

Yield.—Data on the yield of canned fruits purchased from retail markets in the Washington, D.C., area are given in table 11.

The range in weight of all canned fruits per market unit as purchased was quite small, as would be expected with standardized containers and packs. The mean yield of solids plus liquids was 100 percent except for Bing cherries, which had a yield of 92 percent after pits were removed, and red sour cherries, 95 percent, after cooking with sugar added.

Yield of drained solids ranged from about 35 percent for strawberries to 81 percent for baked apples. Servings of drained solids ranged from 1.6 per pound for strawberries to 3.2 for pineapple slices and chunks, with most of the drained fruits falling within the range of 2.0 to 2.8 servings of specified size.

Amounts of solids plus liquid for each serving of specified size ranged from 1.1 ounces of lemon juice to 4.6 ounces of strawberries. Amounts of canned fruit to purchase for one serving of solids plus liquid or of drained solids varied among fruits. A majority of the fruits required from 4.2 to 4.6 ounces for a $\frac{1}{2}$ -cup serving of solids plus liquid. The range of food to purchase for one serving of drained solids was from 4.9 ounces for pineapple slices and chunks to 9.7 ounces for strawberries.

Color, texture, and flavor.—Color-difference meter and shear-force values, and panel evaluations of color, texture, and flavor are shown in tables 12 and 13. Ranges in color-difference meter values and shear-force values for most of the fruits were generally small.

Ranges in panel color scores were not great except for peaches, with scores from 3.2 to 5.0. Cherry sauce and grapefruit sections, each with color scores of 4.9, were rated best in color. Lowest scores were given to red sour cherries, 2.9, and raspberries, 2.3.

Panel texture scores indicated that most of the canned fruits investigated were of somewhat softer than optimum texture. Raspberries, with a score of 1.9, were lowest in panel texture scores.

TABLE 8.—FRESH FRUITS: *Shear values and panel scores*

Fruit	Shear values		Panel scores						Samples
	Mean	Range	Color ¹		Texture ²		Flavor ³		
			Mean	Range	Mean	Range	Mean	Range	
	<i>Lb.</i>	<i>Lb. force</i>							<i>Number</i>
Cherries, dark sweet.....	143	94-192	4. 8	-----	5. 0	-----	4. 9	4. 8-5. 0	2
Cherries, red sour.....	206	192-220	4. 8	-----	5. 0	-----	4. 9	4. 8-5. 0	2
Cranberry sauce:									
Strained.....			5. 0	-----	4. 0	-----	3. 2	-----	1
Whole.....			4. 4	-----	3. 2	-----	4. 2	-----	1
Grapefruit sections.....	206	179-233	4. 8	4. 6-5. 0	4. 6	4. 4-4. 8	4. 6	-----	2
Orange juice:									
Home-squeezed.....			4. 9	4. 8-5. 0	4. 7	4. 6-4. 8	4. 8	-----	2
Store-squeezed.....			5. 0	-----	4. 9	4. 8-5. 0	4. 6	4. 2-5. 0	2
Peaches, sliced.....	32	27-38	4. 6	4. 4-4. 8	4. 8	4. 6-5. 0	4. 5	4. 0-5. 0	2
Plums, cooked.....			4. 0	-----	3. 2	-----	4. 6	-----	1
Raspberries, red.....	63	47-84	4. 9	4. 8-5. 0	4. 9	4. 8-5. 0	4. 5	4. 2-4. 8	2
Rhubarb.....			5. 0	-----	4. 9	4. 8-5. 0	4. 6	4. 4-4. 8	2
Strawberries, whole.....	31	27-38	4. 7	4. 6-4. 8	4. 6	4. 4-4. 8	4. 5	4. 4-4. 6	2

¹ The range was from 5, very good color, to 1, very poor color.

² The range was from 5, characteristic texture, to 1, very poor texture.

³ The range was from 5, very desirable flavor, to 1, very undesirable flavor.

TABLE 9.—FRESH FRUITS: *Color-difference meter values*

Fruit	Color-difference meter values ¹						Samples
	<i>L</i>		<i>a_L</i>		<i>b_L</i>		
	Mean	Range	Mean	Range	Mean	Range	
							<i>Number</i>
Cherries, dark sweet-----	13. 2	12. 4-14. 0	6. 4	2. 6- 10. 2	2. 6	1. 9- 3. 3	2
Cherries, red sour-----	13. 7	13. 1-14. 0	18. 5	15. 9- 20. 6	5. 0	4. 4- 5. 4	2
Cranberry sauce:							
Strained-----	10. 1	-----	18. 1	-----	4. 8	-----	1
Whole-----	9. 0	-----	13. 7	-----	4. 6	-----	1
Grapefruit sections-----	47. 3	45. 5-49. 1	-4. 7	-4. 6- -4. 8	15. 1	14. 7-15. 5	2
Orange juice:							
Home-squeezed-----	42. 0	41. 8-42. 1	-9. 7	-----	25. 1	24. 9-25. 3	2
Store-squeezed-----	40. 6	40. 1-41. 1	-----	-----	26. 8	26. 6-26. 9	2
Peaches, sliced-----	57. 4	55. 6-59. 2	-----	-----	31. 4	30. 3-32. 4	2
Plums, cooked-----	8. 8	-----	12. 4	-----	4. 5	-----	1
Raspberries, red-----	13. 2	11. 3-15. 5	20. 1	18. 4- 21. 5	5. 6	5. 1- 6. 1	2
Strawberries, whole-----	22. 2	21. 4-22. 9	26. 8	25. 4- 28. 1	11. 4	10. 8-12. 0	2

¹ Mean of 5 values on each sample. *L*=visual lightness; *a_L*=redness or greenness; *b_L*=yellowness or blueness.

TABLE 10.—CANNED FRUITS: *Preparation time for family-sized units*

Fruit and preparation form	Market unit		Preparation time ¹		Samples
	Container	Weight	Active	Total	
		<i>Ounces</i>	<i>Minutes</i>	<i>Minutes</i>	<i>Number</i>
Apples, baked.....	No. 2 tall can.....	21.0	¼	¼	3
Cherries, dark sweet (Bing):					
Unpitted.....	No. 303 can.....	16.0	¼	¼	3
Pitted.....	No. 303 can.....	16.0	8	9	3
Cherries, red sour:					
Uncooked.....	No. 303 can.....	16.0	¼	¼	4
Cooked with sugar.....	No. 303 can.....	16.0	3½	9¼	4
Cherry sauce.....	No. 303 can.....	16.0	¼	¼	2
Cranberry sauce:					
Strained.....	No. 300 can.....	16.0	¼	¼	4
Whole.....	No. 300 can.....	16.0	¼	¼	4
Grapefruit sections.....	No. 303 can.....	16.0	¼	¼	5
Lemon juice:					
In plastic lemon.....	1 plastic lemon.....	2.5	3¼	3¼	2
Bottled.....	8-fl.-oz. bottle.....	-----	¼	¼	2
Orange juice.....	No. 2 can.....	-----	¼	¼	4
Peaches, halves.....	No. 2½ can.....	30.0	¼	¼	4
Pineapple slices or chunks.....	No. 2 can.....	20.5	¼	¼	3
Plums, whole, unpeeled.....	No. 2½ can.....	30.0	¼	¼	3
Raspberries, red.....	Can.....	17.0	¼	¼	6
Strawberries.....	No. 1 kitchenette can.....	11.0	¼	¼	4
Strawberry pie filling, without crust.....	No. 2 can.....	22.0	1¼	1¼	4

¹ All fruits were allowed to drain 1 minute if liquid was present as purchased or as prepared, in addition to the time recorded above.

TABLE 11.—CANNED FRUITS: *Yield of prepared food as served*

Fruit and preparation form ¹	Market unit		Actual weight of food per market unit ²		Yield of prepared food as served		Servings					Sam- ples
	Container	Weight on label	Mean	Range	Mean ³	Range	Weight per serving	Approximate size	Servings per market unit as purchased	Servings per pound as purchased	Amount as purchased for 1 serving	Num- ber
		Ounces	Ounces	Ounces	Percent	Percent						
Apples, baked Solids and liquids Drained solids	No. 2 tall can	21.0	21.9	21.5-22.6	100.0							3
					81.0	77.3-82.4	5.6	1 apple	3.2	2.3	6.8	3
	No. 303 can	16.0	17.4	16.9-17.7								
Cherries, dark sweet (Bing) Unpitted: Solids and liquid					100.0							
					51.3	49.3-53.4	4.4	0.5 cup	4.0	3.7	4.4	7
	No. 303 can	16.0	17.4	16.9-17.7	92.1	92.0-92.6	3.5	0.5 cup	2.5	2.3	7.0	7
Cherries, red sour: Pitted, water pack Solids and liquid					43.6	41.6-45.0			2.2	2.0	7.9	7
							3.5	0.5 cup				7
	No. 303 can	16.0	17.0	16.9-17.1	100.0		4.4	0.5 cup				4
Pitted, water pack ⁵ Solids and liquid					68.1	65.1-69.4	3.9	0.5 cup	3.9	3.7	4.4	4
									3.0	2.8	5.7	4
	No. 303 can	16.0	17.0	16.9-17.1	⁵ 94.6	94.0-95.2	4.4	0.5 cup	3.7	3.5	4.6	2
Cherry sauce Solids and liquid	No. 303 can	16.0	16.7	16.5-16.9	100.0		2.5	0.25 cup	6.8	6.5	2.4	2
												2
Cranberry sauce: Strained Solids and liquid	No. 300 can	16.0	16.2	16.0-16.3	100.0		2.4	0.25 cup	6.8	6.7	2.4	4
												4
	No. 300 can	16.0	16.4	16.1-16.8	100.0		2.4	0.25 cup	6.8	6.6	2.4	4
Whole Solids and liquid												

Grapefruit, sections	No. 303 can	16.0	16.8	16.0-17.2	100.0			4.3	0.5 cup	3.9	3.7	4.3	5
Solids and liquid					59.9	55.6-63.1		3.4	0.5 cup	2.9	2.8	5.8	5
Drained solids													
Lemon juice:													
In plastic lemon	1 plastic lemon	2.5	2.9	2.8-2.9	100.0			1.1	2.0 tbsp	2.6	14.3	1.1	2
Solids and liquid													
Bottled	8-oz. bottle		8.8	8.7-8.8	100.0			1.1	2.2 tbsp	8.0	14.5	1.1	2
Solids and liquid													
Orange juice	No. 2 can, 18 fl. oz.		19.8	19.5-19.9	100.0								
Solids and liquid													
Peaches, halves	No. 2½ can	30.0	20.8	29.6-30.2	100.0			4.4	0.5 cup	4.5	3.6	4.4	6
Solids and liquid													
Drained solids					57.1	54.8-58.8		4.4	0.5 cup	6.8	3.7	4.4	4
Solids and liquid								3.7	0.5 cup	4.6	2.5	6.5	4
Pineapple:													
Slices	No. 2 can	20.5	21.2		100.0			4.2	2.1 slices 2.8 tbsp.	5.0	3.8	4.2	3
Solids and liquid													
Drained solids													
Chunks	No. 2 can	20.5	21.2	21.1-21.2	65.6	65.4-65.8		3.2	2.5 slices	4.3	3.2	4.9	3
Solids and liquid													
Drained solids					100.0			4.2	0.5 cup	5.0	3.8	4.2	2
Plums, whole, unpeeled					65.4	64.5-66.5		3.2	0.4 cup	4.3	3.2	4.9	2
Solids and liquid	No. 2½ can	30.0	30.7	30.1-31.2	100.0								
Drained solids					53.3	52.7-54.2		4.4	0.5 cup	7.0	3.6	4.4	3
Raspberries, red	Can	17.0	17.5	17.4-17.6				3.7	0.5 cup	4.4	2.3	7.0	3
Solids and liquid													
Drained solids					100.0			4.5	0.5 cup	3.9	3.6	4.5	4
Strawberries	No. 1 kitchen- ette can	11.0	10.7	10.6-10.8	39.6	35.3-43.3		2.6	0.4 cup	2.6	2.4	6.7	4
Solids and liquid													
Drained solids					100.0			4.6	0.5 cup	2.3	3.5	4.7	4
Strawberry pie filling					34.7	32.4-36.7		3.5	0.4 cup	1.1	1.6	9.7	4
Solids and liquid	No. 2 can	22.0	21.9	21.6-22.0	100.0			4.6	0.5 cup	4.8	3.5	4.6	4

¹ See table 2 for steps in preparing canned fruits.

² All foods were weighed in grams, and weights were converted to ounces.

³ Based on actual weight of food per market unit and weight of prepared food.

⁴ Weight before pitting.

⁵ Cooked with sugar in the laboratory. See table 3 for ingredients added to cooked fruits.

TABLE 12.—CANNED FRUITS: *Color-difference meter values*

Fruit	Color-difference meter values ¹						Samples	
	<i>L</i>		<i>a_L</i>			<i>b_L</i>		
	Mean	Range	Mean	Range		Mean		Range
Cherries, dark sweet.....	9.9	9.1-10.7	4.0	3.7-	4.4	1.0	0.7- 1.3	<i>Number</i> 2
Cherries, red sour:								
Uncooked.....	27.8	27.6-28.1	16.0	15.9-	16.0	13.6	13.4-13.9	2
Cooked.....	23.9	23.6-24.2	15.6	15.0-	16.2	11.9	11.8-12.0	2
Cherry sauce.....	12.9	12.8-13.0	20.6	18.7-	22.4	6.1	5.8- 6.4	2
Cranberry sauce:								
Strained.....	7.4		7.1			2.4		1
Whole.....	9.0		9.1			3.1		1
Grapefruit sections.....	48.2	45.5-50.8	-3.8	-3.2-	-4.4	18.0	17.6-18.3	2
Orange juice.....	46.7	41.8-49.1	-.8	-.4-	-1.2	27.0	23.4-28.4	4
Peaches, halves.....	45.2	43.0-47.3				27.0	24.2-29.7	2
Plums.....	10.2		7.9			4.0		1
Raspberries, red.....	17.4	15.9-18.9	12.8	11.7-	13.9	5.2	4.3- 6.0	2
Strawberries, whole.....	16.9		13.5			7.3		1

¹ Mean of 5 values on each sample. *L*=visual lightness; *a_L*=redness or greenness; *b_L*=yellowness or blueness.

TABLE 13.—CANNED FRUITS: *Shear values and panel scores*

Fruit	Shear values		Panel scores						Samples
	Mean	Range	Color ¹		Texture ²		Flavor ³		
			Mean	Range	Mean	Range	Mean	Range	
	<i>Lb. force</i>								<i>Number</i>
Apples, baked.....			4. 0		3. 6		4. 0		1
Cherries, dark sweet.....	79	74- 84	4. 0	3. 8-4. 2	4. 2	3. 8-4. 6	4. 1	4. 0-4. 2	2
Cherries, red sour:									
Uncooked.....	51	47- 55							2
Cooked.....	32	27- 38	2. 9	2. 8-3. 0	3. 7	3. 6-3. 8	3. 8		2
Cherry sauce.....			4. 9	4. 8-5. 0	4. 6	4. 4-4. 8	4. 6	4. 4-4. 8	2
Cranberry sauce:									
Strained.....			4. 0		4. 0		3. 6		1
Whole.....			4. 6		3. 8		4. 6		1
Grapefruit sections.....	110	88-132	4. 9	4. 8-5. 0	4. 4	4. 2-4. 6	3. 8	3. 4-4. 2	2
Orange juice.....			4. 4	4. 2-4. 6	4. 5	4. 0-5. 0	3. 5	3. 4-3. 6	4
Peaches, halves.....	22	18- 27	4. 1	3. 2-5. 0	3. 8	3. 4-4. 2	3. 3	3. 2-3. 4	2
Plums.....			3. 0		3. 6		2. 8		1
Raspberries, red.....			2. 3	2. 0-2. 6	1. 9	1. 4-2. 4	2. 3	2. 2-2. 4	2

¹ The range was from 5, very good color, to 1, very poor color.

² The range was from 5, characteristic texture, to 1, very poor texture.

³ The range was from 5, very desirable flavor, to 1, very undesirable flavor.

Canned fruits with good flavor or scores near 4 or above were dark sweet cherries, cherry sauce, cranberry sauce, baked apples, and grapefruit sections. Those with fair flavor quality were orange juice, peaches, and plums.

Frozen Fruits

Preparation time.—Active preparation time was less than 1 minute for all frozen fruits except lemonade, orange juice, and rhubarb, which required from 2½ to 4½ minutes (table 14).

Total preparation time was longest for baked apples, about 180 minutes, because of the time required for defrosting. Red sour cherries, grapefruit, and pineapple chunks required next longest times, ranging from about 120 to 75 minutes. Lemonade and orange juice concentrates required comparatively little total preparation time, 2½ minutes in each case. Time required for other fruits ranged from about 50 to 61 minutes.

Yield.—In table 15 are given data on values and ranges for the net weight of the frozen fruits as purchased, yield of solids plus liquids, and yield of drained solids. Also given are weight of servings, approximate size of serving, number of servings per market unit, servings per pound, and amount needed for one serving.

Market units for fruits differed little in weight among the fruits studied. Widest ranges were found in baked apples, grapefruit, and whole strawberries. Yields were 100 percent except for fruits to which ingredients were added. For orange juice, the weight of the reconstituted product was 3.69 times that of the concentrate. The weight of rhubarb likewise increased to about 120 percent of the as-purchased fruit.

The yield of drained solids ranged from about 44 percent for sliced strawberries to 100 percent

for baked apples. Other fruits ranged from about 47 to 61 percent in yield of drained solids.

The calculated servings per pound for solids plus liquids ranged from 3.4 to 3.8 for all fruits except orange juice concentrate, which was 13.4, and rhubarb, 4.6, both of which had added ingredients. The number of servings per pound for drained solids ranged from 2.1 for rhubarb and sliced and whole strawberries to 3.0 for pineapple chunks.

Amounts of frozen fruits to purchase for one serving of solids plus liquids ranged from 1.2 ounces for orange juice concentrate to 4.6 ounces for sliced and whole strawberries. Most fruits, however, required from 4.2 to 4.6 ounces of fruit as purchased, per individual serving. Amounts of frozen fruit to purchase for one serving of drained solids ranged from 5.4 ounces for pineapple chunks to 7.7 ounces for sliced strawberries.

Ascorbic acid.—Reduced ascorbic acid and its oxidation product, dehydroascorbic acid, are important because of their biological activity as Vitamin C. In the freshly harvested fruit, ascorbic acid would be present chiefly in the reduced form. The Western Utilization Research and Development Division found that in a frozen fruit stored at 0° F. or below, the ratio of oxidized to reduced ascorbic acid should be very low. Above 0° F., reduced ascorbic acid oxidizes to dehydroascorbic acid and diketogulonic acid, thus increasing the ratio. The amount of increase indicates the extent of storage above 0° F.

In table 16 are shown values and ranges for reduced ascorbic acid and ratios of dehydroascorbic acid plus diketogulonic acid to reduced ascorbic acid in the six frozen fruits investigated. Results are given for both solids and liquids. Ratios of ascorbic acid in solids to ascorbic acid in liquids are also given. Since all the brands of

TABLE 14.—FROZEN FRUITS: *Preparation time for family-sized units*

Fruit and preparation form	Market unit		Preparation time ¹		Samples
	Container	Weight	Active	Total	
		Ounces	Minutes	Minutes	Number
Apples, baked.....	Paper package.....	12. 0	½	180½	4
Cherries, red sour.....	Metal can.....	20. 0	¼	120½	4
Grapefruit, sections.....	Metal can.....	13. 5	¾	85¾	6
Lemonade concentrate.....	6-fl.-oz. can.....		2½	2½	2
Orange juice concentrate.....	6-fl.-oz. can.....		2½	2½	4
Peaches, sliced.....	Paper package, metal ends.....	10. 0	¼	60¼	4
Pineapple, chunks.....	Metal can.....	13. 5	¼	75¼	3
Raspberries, red.....	Paper package.....	10. 0	¾	50¾	5
Rhubarb, cooked.....	Paper package.....	16. 0	4½	56	3
Strawberries:					
Sliced.....	Paper package, metal ends.....	10. 0	¼	60¼	6
Whole.....	Paper package, metal ends.....	16. 0	½	55½	6

¹ All fruits were allowed to drain 1 minute if liquid was present as purchased or as prepared, in addition to the time recorded above.

TABLE 15.—FROZEN FRUITS: *Yield of prepared food as served*

Fruit and preparation form ¹	Weight of food per market unit ²		Yield of prepared food as served		Servings					Samples	
	Labeled weight of market unit	Weight of food per market unit ²		Mean ³	Range	Weight per serving	Approximate size	Servings per market unit as purchased	Servings per pound as purchased		Amount as purchased needed for 1 serving
		Mean	Range					Number	Number		
Apples, baked Drained solids	Ounces 12. 0	Ounces 11. 2	Ounces 9. 9-12. 2	Percent 100. 0	Percent	Ounces 5. 6	1 apple	2. 0	2. 9	Ounces 5. 6	Number 4
Cherries, red sour: Pitted, sirup pack	20. 0	20. 6	20. 3-21. 0	100. 0		4. 4	0.5 cup	4. 7	3. 7	4. 4	4
Solids and liquid				61. 4	58. 4- 62. 7	3. 9	.4 cup	3. 3	2. 6	6. 2	4
Drained solids	13. 5	14. 5	13. 7-15. 2	100. 0		4. 3	.5 cup	3. 4	3. 8	4. 3	6
Grapefruit, sections				59. 5	57. 1- 64. 3	3. 4	.5 cup	2. 5	2. 8	5. 8	6
Solids and liquid						4. 4	.5 cup	6. 2	13. 4	1. 2	4
Drained solids		7. 4	7. 4- 7. 5	* 369. 2	365. 1-371. 1	4. 4	.5 cup				
Orange juice concentrate		9. 9	9. 8-10. 0	100. 0		4. 4	.5 cup	2. 2	3. 6	4. 5	4
Solids and liquid	10. 0			58. 7	57. 9- 59. 2	3. 7	.5 cup	1. 6	2. 6	6. 2	4
Peaches, sliced		13. 4	13. 2-13. 6	100. 0		4. 2	.5 cup	3. 2	3. 8	4. 2	3
Drained solids				60. 2	53. 9- 68. 3	3. 2	.5 cup	2. 5	3. 0	5. 4	3
Pineapple chunks		10. 2	10. 0-10. 4	100. 0		4. 5	.5 cup	2. 3	3. 6	4. 4	5
Solids and liquids				47. 1	39. 7- 57. 4	2. 6	.4 cup	1. 8	2. 8	5. 7	5
Drained solids		15. 6	15. 5-15. 7	* 119. 6	118. 7-119. 9	4. 2	.5 cup	4. 5	4. 6	3. 5	3
Raspberries, red				57. 1	55. 8- 58. 2	4. 5	.5 cup	2. 0	2. 1	7. 8	3
Solids and liquid											
Drained solids											
Rhubarb	16. 0										
Solids and liquid											
Drained solids											
Strawberries:											
Sliced	10. 0	10. 0	9. 9-10. 2	100. 0		4. 6	.5 cup	2. 2	3. 5	4. 6	6
Solids and liquid				44. 2	42. 4- 47. 6	3. 5	.4 cup	1. 3	2. 1	7. 7	6
Drained solids											
Whole	16. 0	16. 7	15. 8-17. 4	100. 0		4. 6	.5 cup	3. 6	3. 4	4. 6	6
Solids and liquid				46. 9	35. 4- 56. 9	3. 5	.5 cup	2. 2	2. 1	7. 6	6
Drained solids											

¹ See table 2 for steps in preparation of frozen fruits.² All foods were weighed in grams, and weights were converted to ounces.³ Based on actual weight of food per market unit and weight of prepared food.⁴ See table 3 for sugar added to fruits.

frozen peaches contained added ascorbic acid, the values were higher than those normally found in fresh fruit. All fruits investigated varied in ascorbic acid content of both solids and liquids. For each type of fruit, a few samples showed extreme variation. However, values for most of the samples fell near the mean for the group. This is demonstrated by the fact that a large proportion of the samples (ranging from 63 of 64 samples for orange juice to 35 of 48 for peaches and raspberries) had ascorbic acid values at least 80 percent as high as the mean ascorbic acid value for that particular fruit.

The ratio of oxidized to reduced ascorbic acid in solids was highest in raspberries, 0.71; this fruit was also most variable in oxidation ratios, with a range of 0.22 to 8.75. In grapefruit, most of the ascorbic acid was in the reduced form; the oxidation ratio in solids was only 0.11. For the other fruits, the ratios ranged from 0.51 in pineapple to 0.60 in strawberries. As was the case with reduced ascorbic acid, a few extreme values were responsible for much of the variation in

individual values. A large proportion of the samples (ranging from 41 of 48 samples for raspberries to 35 of 48 for grapefruit and peaches) had ascorbic acid oxidation values that exceeded the mean value by no more than 20 percent. Distribution of ascorbic acid oxidation ratios for the fruits investigated are shown in figure 1.

Ratios of oxidized to reduced ascorbic acid in liquids were similar to those for solids. In the liquids, ratios of oxidized to reduced ascorbic acid were very low for grapefruit, 0.08, and orange juice, 0.09. Highest values were obtained in raspberries, 2.06, and strawberries, 1.15. Raspberries had the widest range in oxidation ratios, 0.20 to 4.61, and the highest coefficient of variation, 74, for oxidation ratios.

The low oxidation ratios found in both the solid and liquid portions of grapefruit appear to denote good ascorbic acid stability in this fruit rather than superior storage conditions, since the results of other quality evaluations for grapefruit are similar to those obtained for the other fruits investigated. The ascorbic acid oxidation ratio

TABLE 16.—FROZEN FRUITS: *Ascorbic acid*

Fruit	Solids								
	AsA ¹ (mg./100 g.)			DH+DK ² (mg./100 g.)			$\frac{DH+DK}{AsA}$		
	Mean ³	Range	C.V. ⁴	Mean ³	Range	C.V. ⁴	Mean ³	Range	C.V. ⁴
Grapefruit sections.....	39.3	22.5-48.7	14	4.3	2.2-7.2	34	0.11	0.04-0.19	37
Orange juice concentrate.....									
Peaches, sliced.....	17.5	8.9-28.2	25	9.3	5.0-13.8	23	.58	.18-1.35	43
Pineapple chunks.....	7.3	4.2-14.0	27	3.6	.5-16.0	83	.51	.07-2.00	82
Raspberries, red.....	12.9	.8-23.0	38	5.9	3.0-18.0	41	.71	.22-8.75	180
Strawberries, sliced.....	36.0	11.3-50.2	19	20.3	10.5-32.0	23	.60	.29-1.82	43
	Liquids								
	Mean ³	Range	C.V. ⁴	Mean ³	Range	C.V. ⁴	Mean ³	Range	C.V. ⁴
	Mean ³	Range	C.V. ⁴	Mean ³	Range	C.V. ⁴	Mean ³	Range	C.V. ⁴
Grapefruit sections.....	60.8	34.3-78.0	13	5.2	2.0-11.0	43	0.08	0.04-0.17	36
Orange juice concentrate.....	41.0	32.7-51.0	7	3.5	0-5.8	30	.09	0-.16	30
Peaches, sliced.....	64.5	36.9-102.6	15	17.4	8.8-25.5	16	.28	.12-.50	27
Pineapple chunks.....	8.2	4.0-14.0	23	4.0	.8-12.0	68	.51	.09-1.70	69
Raspberries, red.....	7.3	0-13.0	29	7.0	2.0-27.0	59	1.13	.20-4.61	74
Strawberries, sliced.....	32.7	13.7-55.0	20	20.7	10.0-36.0	28	.69	.30-1.43	54
	AsA in solids/AsA in liquids								
	Mean ³			Range			C.V. ⁴		
	Mean ³			Range			C.V. ⁴		
Grapefruit sections.....	0.66			0.43-1.09			20		
Orange juice concentrate.....									
Peaches, sliced.....	.27			.14-.53			27		
Pineapple chunks.....	.90			.62-1.49			18		
Raspberries, red.....	2.06			.10-6.76			54		
Strawberries, sliced.....	1.12			.30-1.59			15		

¹ Reduced ascorbic acid.

² Dehydroascorbic acid plus diketogulonic acid.

³ Mean of 48 samples, except for orange juice concentrate which is a mean of 64 samples.

⁴ Coefficient of variation.

was very low also for orange juice. This was expected, since ascorbic acid in orange juice is known to be quite stable.

Ratios of ascorbic acid in solids to ascorbic acid in liquids are shown in table 16. In a fruit that has been subjected to storage temperatures high

enough to permit thawing, there is transfer of ascorbic acid from solids to liquids, causing a decrease in the ascorbic acid ratio.

Lowest ratios were obtained for frozen peaches. However, since this fruit contained added ascorbic acid, low ratios would be expected. Wide varia-

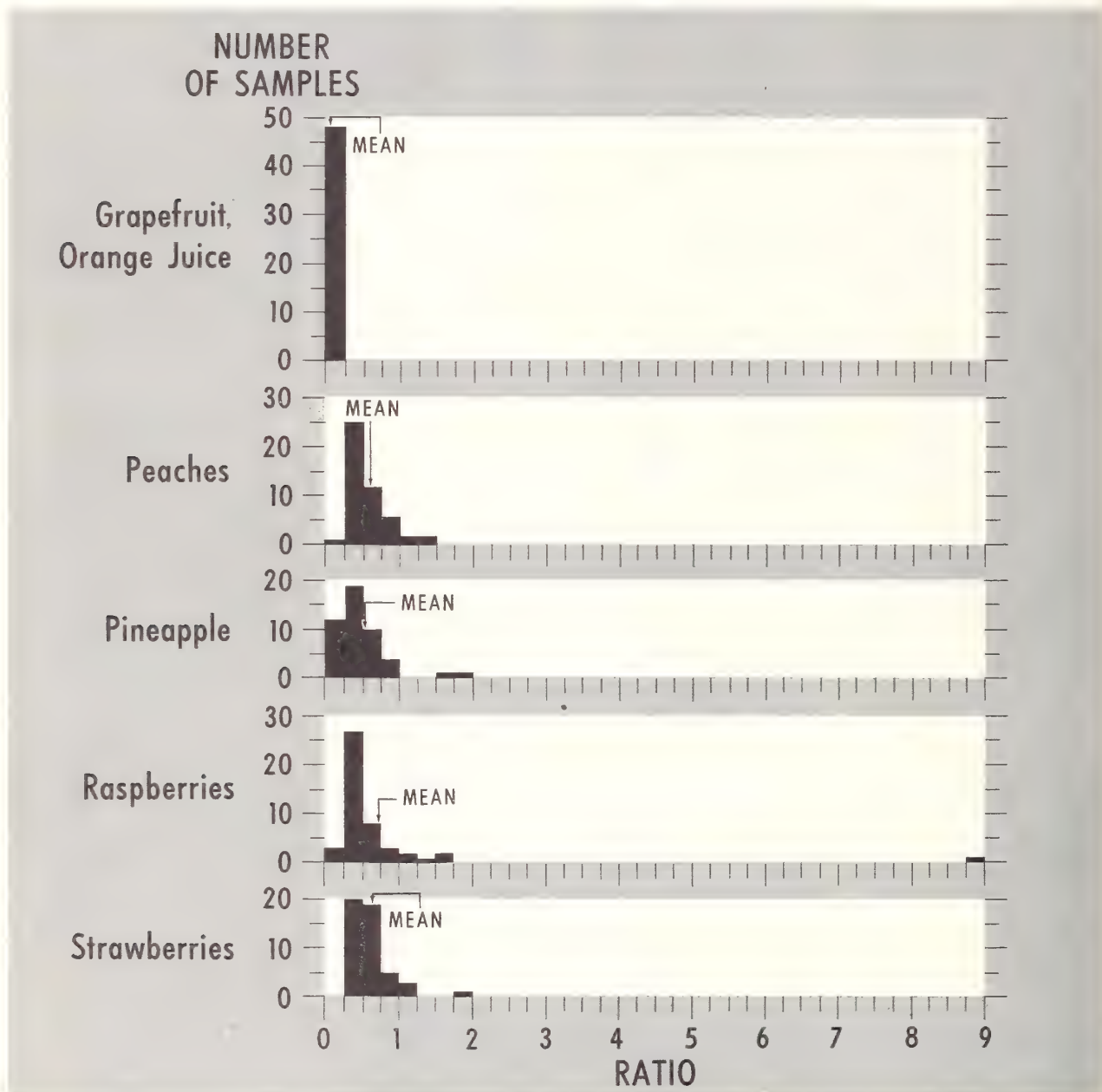


FIGURE 1.—FROZEN FRUITS: Ratios of oxidized to reduced ascorbic acid.

tions in ascorbic acid ratios in the other fruits investigated suggested a considerable range in storage history. In most cases, the majority of the ratios were in the range 0.50 to 1.25; raspberries were an exception—seventeen of the samples tested had ratios greater than 2.00. Distribution of solids-to-liquids ratios of ascorbic acid for the fruits investigated are shown in figure 2.

Titrateable acidity.—In work on frozen rasp-

berries, reported by Guadagni and others (8), it was found that the total acid ratio could be used as an indicator of storage history. The ratio of total acid in fruit to that in liquid was found to drop markedly within one to two weeks of storage at 20° F.

In table 17 are shown ranges and mean values for titrateable acidity ratios for the fruits investigated except orange juice. In most cases, the

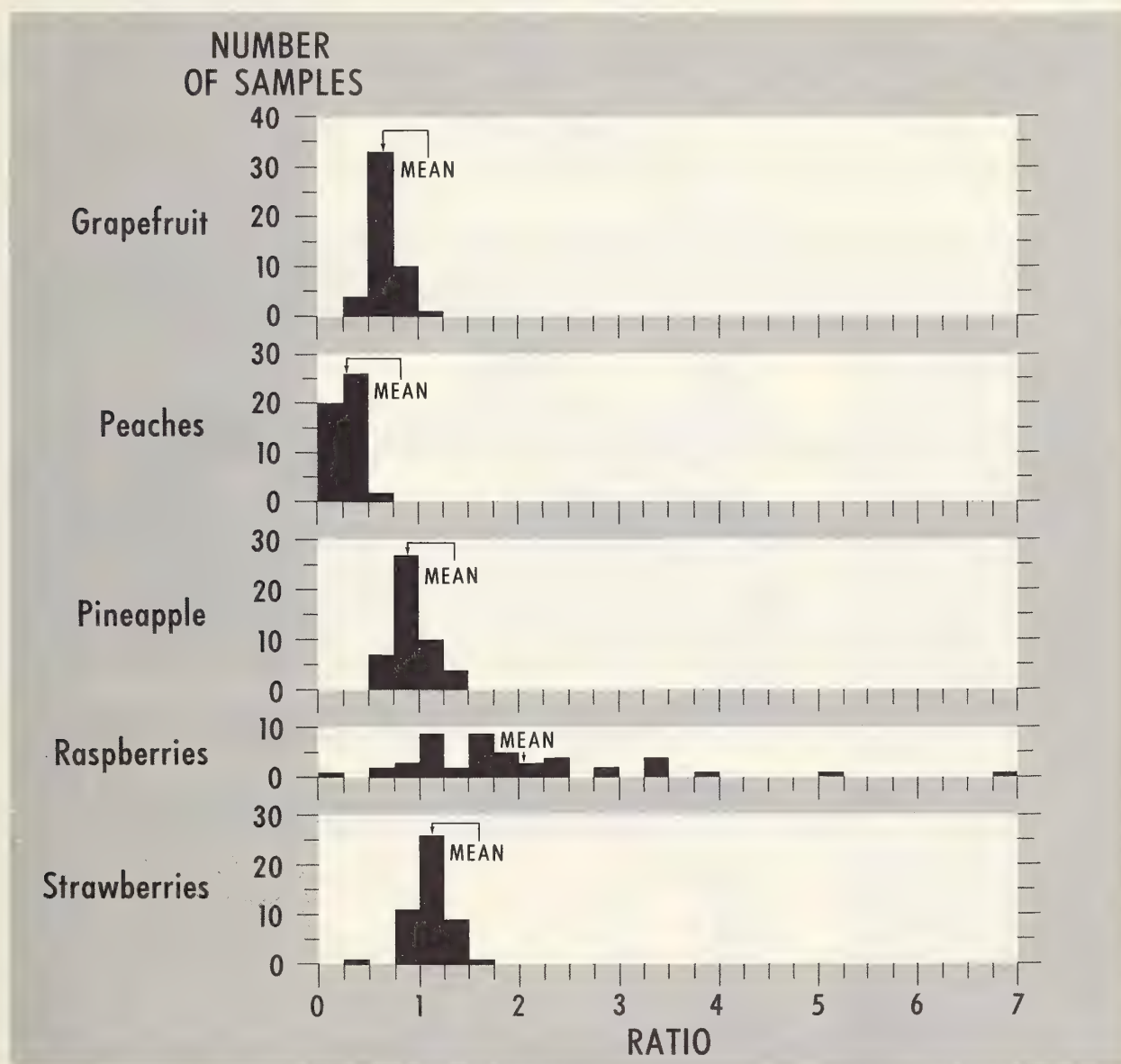


FIGURE 2.—FROZEN FRUITS: Solids-to-liquids ratios of ascorbic acid.

results do not differ greatly from those obtained for ascorbic acid ratios. Raspberries, which were highest in ascorbic acid ratios, 2.06, were also highest in titratable acidity ratios, 2.55. Acid ratios appear to be characteristically higher for raspberries than for other fruits investigated. A summary of sample distribution in accordance with this quality evaluation factor is given in figure 3. Titratable acidity ratios for strawberries and pineapple were similar to ascorbic acid ratios for these fruits. The titratable acidity ratio for grapefruit, however, was considerably higher than the ascorbic acid ratio for this fruit. In peaches, the added ascorbic acid would probably be a factor in the ascorbic acid ratio, and similarity of this ratio to the titratable acidity ratio would not be expected.

Guadagni and others (9), in work on frozen raspberries of known history, have reported titratable acidity ratios ranging from 1.05 to 1.27 for samples subjected to storage at 20° F. for 5 days. Since most of the samples of raspberries had

titratable acidity ratios of 1.25 or less, it would seem that they had been stored under conditions more favorable than 5 days at 20° F.

Effects of time and temperature on solids-to-liquids ratios of titratable acidity have been reported for raspberries only. The data in figure 3 would indicate that the rate of migration of acid from solids to liquids is a characteristic of the individual fruit. Results for fruits other than raspberries can therefore be evaluated best when related to those of other quality evaluation tests. In grapefruit, pineapple, and strawberries, the ratios were generally low. In peaches, the wide range in values would seem to denote considerable variation in storage history.

Soluble solids.—In the freshly frozen fruit, most of the soluble solids would be in the liquid portion of the fruit. Consequently the solids-to-liquids ratio of soluble solids would be quite low. If the fruit is exposed to temperatures above 0° F., some of the soluble solids will migrate from the liquid to the solid portion of the fruit

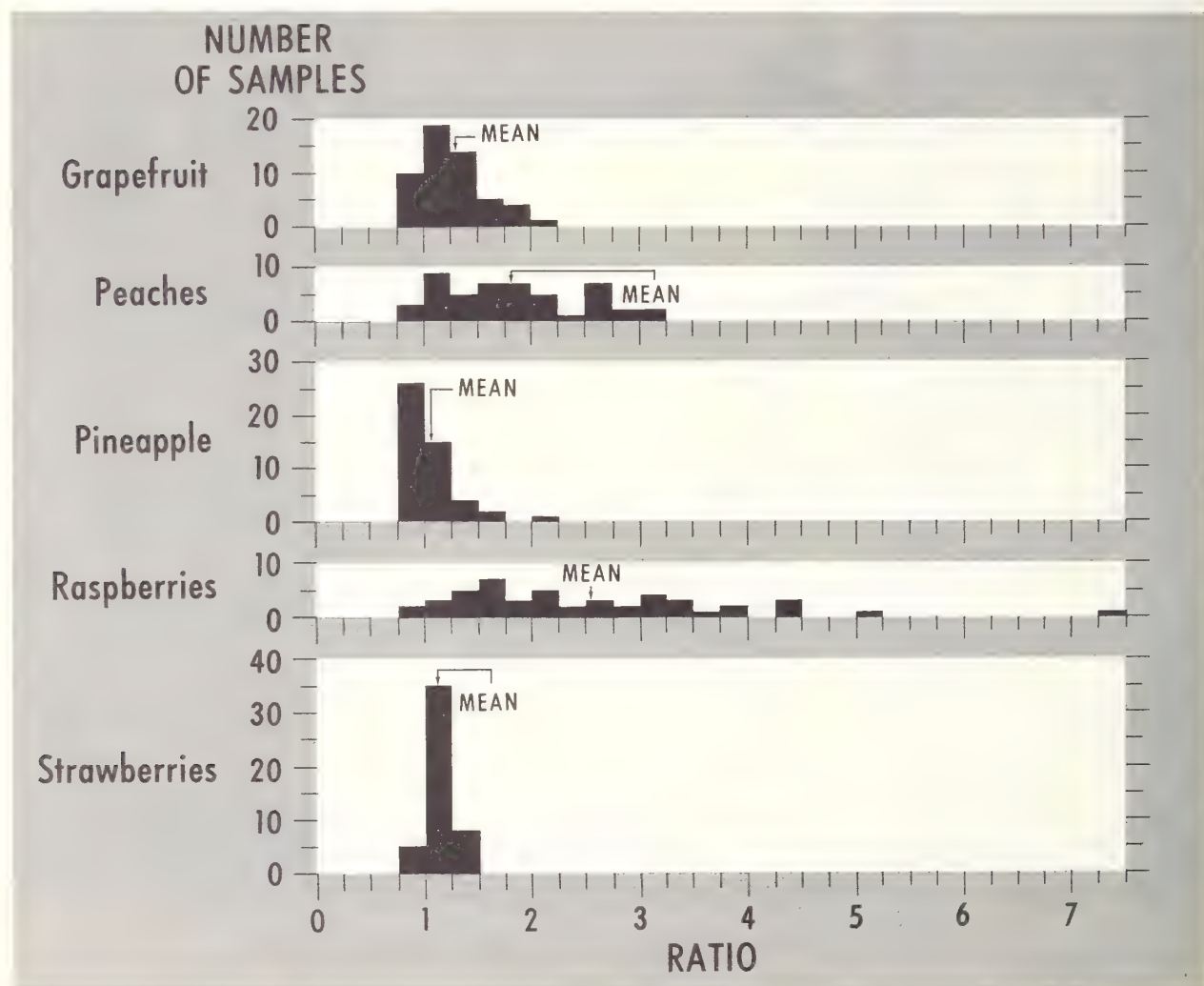


FIGURE 3.—FROZEN FRUITS: Solids-to-liquids ratios of titratable acids.

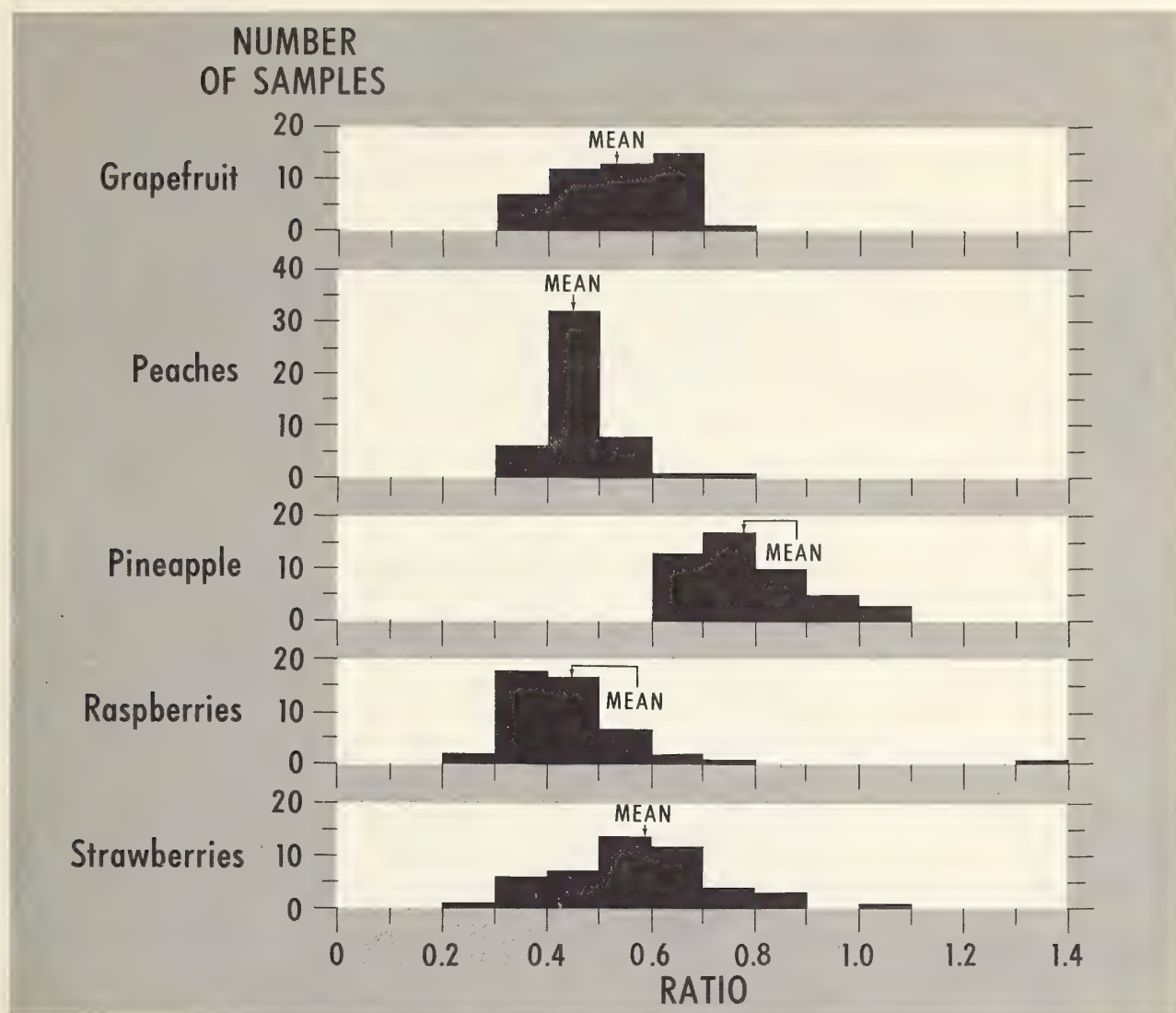


FIGURE 4.—FROZEN FRUITS: Solids-to-liquids ratios of soluble solids.

and the solids-to-liquids ratio of soluble solids will increase. The ratio would also be related to initial quality and ripeness of fruit and affected by the concentration of sugar used in the syrup of the frozen fruit. Consequently, the soluble solids ratio cannot be used as an absolute value for estimating storage history.

Work reported by Guadagni and others (8) has disclosed that a ratio of 0.7 was maintained in freshly processed strawberries stored for 50 days at 10° F. In raspberries stored at 20° F. for 48 days, the ratio increased only slightly, from about 0.50 to 0.53. Storage at temperatures above 20° F. caused further increases in soluble solids ratios. Ratios of 0.9 or above indicated thawing of the fruit.

In the work reported here on retail market samples, considerable range in soluble solids ratios was encountered (table 18). Lowest values,

0.45, were obtained for peaches and raspberries. Pineapple, with a value of 0.78 and a range of 0.60 to 1.10, was highest.

A summary of the sample distribution according to soluble solids ratios is given in figure 4. Only a few of the ratios for strawberries exceeded 0.70. Only a few of those for raspberries exceeded 0.50. These ratios would seem to indicate generally good storage history for these fruits. The distribution of soluble solids ratios for grapefruit was similar to that of strawberries. Ratios for peaches ranged slightly above those for raspberries.

Color.—Values and ranges for color-difference meter and panel color scores are shown in tables 19 and 20. The color-difference meter standards were selected to correspond as nearly as possible to the color of the fruit investigated. Since this made necessary the use of several color standards,

TABLE 17.—FROZEN FRUITS: *Titratable acidity*

Fruit	Titratable acidity ¹								
	Solids			Liquids			Solids/Liquids		
	Mean ²	Range	C.V. ³	Mean ²	Range	C.V. ³	Mean ²	Range	C.V. ³
	<i>Percent</i>	<i>Percent</i>		<i>Percent</i>	<i>Percent</i>				
Grapefruit sections-----	0.98	0.62-1.80	22	0.77	0.50-1.20	21	1.30	0.79-2.05	20
Peaches, sliced-----	.47	.28-.91	20	.28	.13-.58	20	1.82	.68-3.24	19
Pineapple chunks-----	.54	.22-.87	9	.53	.23-1.02	6	1.05	.75-2.15	-----
Raspberries, red-----	1.36	.71-2.29	16	.63	.22-1.28	28	2.55	.95-7.32	39
Strawberries, sliced-----	.64	.49-1.18	15	.59	.41-.88	14	1.13	.92-1.47	9

¹ Expressed as percent citric acid.³ Coefficient of variation.² Mean of 48 samples.TABLE 18.—FROZEN FRUITS: *Soluble solids*

Fruit	Soluble solids								
	Solids			Liquids			Solids/Liquids		
	Mean ¹	Range	C.V. ²	Mean ¹	Range	C.V. ²	Mean ¹	Range	C.V. ²
	<i>Percent</i>	<i>Percent</i>		<i>Percent</i>	<i>Percent</i>				
Grapefruit, sections-----	14.0	10.3-17.7	11	26.0	21.6-34.5	9	0.53	0.36-0.70	13
Peaches, sliced-----	16.1	12.1-24.6	11	35.7	29.2-41.2	6	.45	.33-.76	14
Pineapple chunks-----	20.6	17.3-25.6	34	26.9	22.1-30.7	37	.78	.60-1.10	16
Raspberries, red-----	16.4	11.0-29.0	19	38.0	21.0-53.0	16	.45	.25-1.38	40
Strawberries, sliced-----	20.4	9.0-33.0	21	35.1	18.0-45.0	12	.59	.21-1.04	22

¹ Mean of 48 samples.² Coefficient of variation.TABLE 19.—FROZEN FRUITS: *Color-difference meter values*

Fruit	Color-difference meter values ¹								
	<i>L</i>			<i>a_L</i>			<i>b_L</i>		
	Mean ²	Range	C.V. ³	Mean ²	Range	C.V. ³	Mean ²	Range	C.V. ³
Grapefruit sections-----	47.8	45.2-50.2	3	5.4	4.5- 6.0	5	15.5	13.9-17.5	4
Orange juice concentrate----	46.7	43.4-50.9	3	-1.9	-5.1--0.6	56	26.7	21.7-29.2	4
Peaches, sliced-----	44.4	33.1-51.7	9	17.8	10.7- 24.3	15	25.6	16.7-30.9	11
Pineapple chunks-----	47.0	42.3-50.1	4	4.8	2.1- 9.3	28	24.3	20.5-27.5	6
Raspberries, red-----	13.5	8.6-18.5	13	26.2	17.6- 31.4	10	6.6	4.2- 8.5	14
Strawberries, sliced-----	19.4	13.6-27.3	13	26.3	21.0- 31.0	7	9.8	7.0-13.3	14

¹ Mean of 5 values on each sample. *L*=visual lightness; *a_L*=redness or greenness; *b_L*=yellowness or blueness.

which is a mean of 64 samples.

³ Coefficient of variation.² Mean of 48 samples, except for orange juice concentrate

TABLE 20.—FROZEN FRUITS: *Shear values and panel scores*

Fruit	Shear values			Color			Texture			Flavor		
	Mean ²	Range	C.V. ³	Mean ²	Range	C.V. ³	Mean ²	Range	C.V. ³	Mean ²	Range	C.V. ³
	<i>Lb. force</i>	<i>Lb. force</i>										
Grapefruit sections	214	144-392	19	4.8	4.2-5.0	6	5.1	4.6-6.0	10	3.8	2.4-4.8	13
Orange juice concentrate	---	---	---	4.6	3.6-5.0	6	4.6	3.8-5.0	6	4.2	2.4-5.0	10
Peaches, sliced	76	43-160	37	4.2	3.2-5.0	9	5.1	3.8-7.0	14	3.8	2.6-4.6	11
Pineapple chunks	490	310-660	14	4.4	3.8-5.0	6	4.8	2.8-5.2	9	4.0	2.6-5.0	12
Raspberries, red	170	113-232	38	3.8	1.8-4.8	13	4.0	2.8-4.8	11	4.0	2.6-5.0	14
Strawberries, sliced	69	46-110	15	3.7	1.8-5.0	20	2.8	1.6-4.8	21	3.4	1.4-5.0	26

¹ See table 5 for description of scales.

² Mean of 48 samples, except for orange juice concentrate, which is a mean of 64 samples.

³ Coefficient of variation.

comparisons of color-difference meter readings can be made between only those fruits for which the same color standard was used (grapefruit and pineapple; raspberries and strawberries).

Of the fruits investigated, grapefruit appeared to vary least in color. This is indicated by the comparatively low ranges in color-difference meter readings and panel color scores and by the high panel score, 4.8. Color-difference meter L and a_L values for pineapple were similar to those for grapefruit, but somewhat more variable. The b_L values for pineapple were higher than the corresponding value for grapefruit, indicating a more yellow color. Panel color scores for both pineapple, 4.4, and orange juice, 4.6, indicated generally good color for these fruits.

Color-difference meter readings for frozen peaches covered a wide range. The presence of brown spots on some of the samples investigated was responsible for much of this variation. This is reflected particularly by the wide range in color-difference meter L values, 33.1 to 51.7.

The red fruits, raspberries and strawberries, showed the greatest variation in color. These fruits ranged in color from the characteristic bright red of the fresh berry to extremely dark red. This is shown by the wide ranges in color-difference meter L and a_L values and in panel color scores. Panel color scores were lowest for strawberries, 3.7, and raspberries, 3.8. A summary of sample distribution according to panel color scores is shown in figure 5.

Texture.—Texture of the frozen fruits was evaluated by panel texture scores and, except for orange juice, by shear-force readings. Results are shown in table 20. Distribution of panel texture scores for the fruits investigated is shown in figure 6.

Grapefruit, with a range in panel scores of 4.6 to 6.0 and a mean value of 5.1, was of consistently good texture. Somewhat greater ranges in texture scores were obtained for peaches and pineapple. Mean texture scores for these fruits, however, were near optimum.

Raspberries, with a range in panel scores of 2.8 to 4.8 and a mean value of 4.0, were considered to be slightly softer than optimum in texture. The texture of frozen strawberries was generally too soft, ranging from 1.6 to 4.8 with a mean of 2.8. Soft texture is often characteristic of frozen strawberries and does not necessarily indicate storage at temperatures above 0° F.

Orange juice was rated for consistency rather than firmness of texture. Therefore, the panel scores cannot be compared directly with those for the other fruits.

Shear values, except for peaches, generally agreed with panel texture scores. Shear values for peaches were lower than would be expected on the basis of the panel texture scores.

Flavor.—A summary of sample distribution in accordance with panel flavor scores is shown in figure 7. Means, ranges, and coefficients of variations are given in table 20. Panel flavor scores, except for strawberries, ranged from 3.8 for peaches and grapefruit to 4.2 for orange juice. Strawberries had the widest sample-to-sample range, 1.4 to 5.0, and the lowest panel score, 3.4.

Cloud.—McColloch and Rice (15) evaluated the quality of orange juice concentrate by determining cloud on reconstituted samples immediately (thawing index) and after storage at 40° F. for 24 hours (sensitivity index). They reported a decrease in the ratio of sensitivity index to thawing index in samples that had been subjected to storage at temperatures above 0° F. The values obtained for the samples investigated here are given in table 21. They are similar to those reported by McColloch and Rice for samples stabilized against cloud loss by heat treatment, and they indicate generally good storage conditions for the orange juice concentrate investigated.

TABLE 21.—FROZEN ORANGE JUICE CONCENTRATE: *Cloud values of samples from selected retail markets during four seasons*

Fruit and season	Cloud		
	TI ¹	SI ²	SI TI
Orange juice concentrate (reconstituted):	<i>OD</i> ³	<i>OD</i> ³	
Spring-----	0.50	0.47	0.94
Summer-----	.58	.57	.98
Fall-----	.56	.52	.93
Winter-----	.55	.56	1.03

¹ Thawing index.

² Sensitivity index.

³ Values are expressed as optical density.

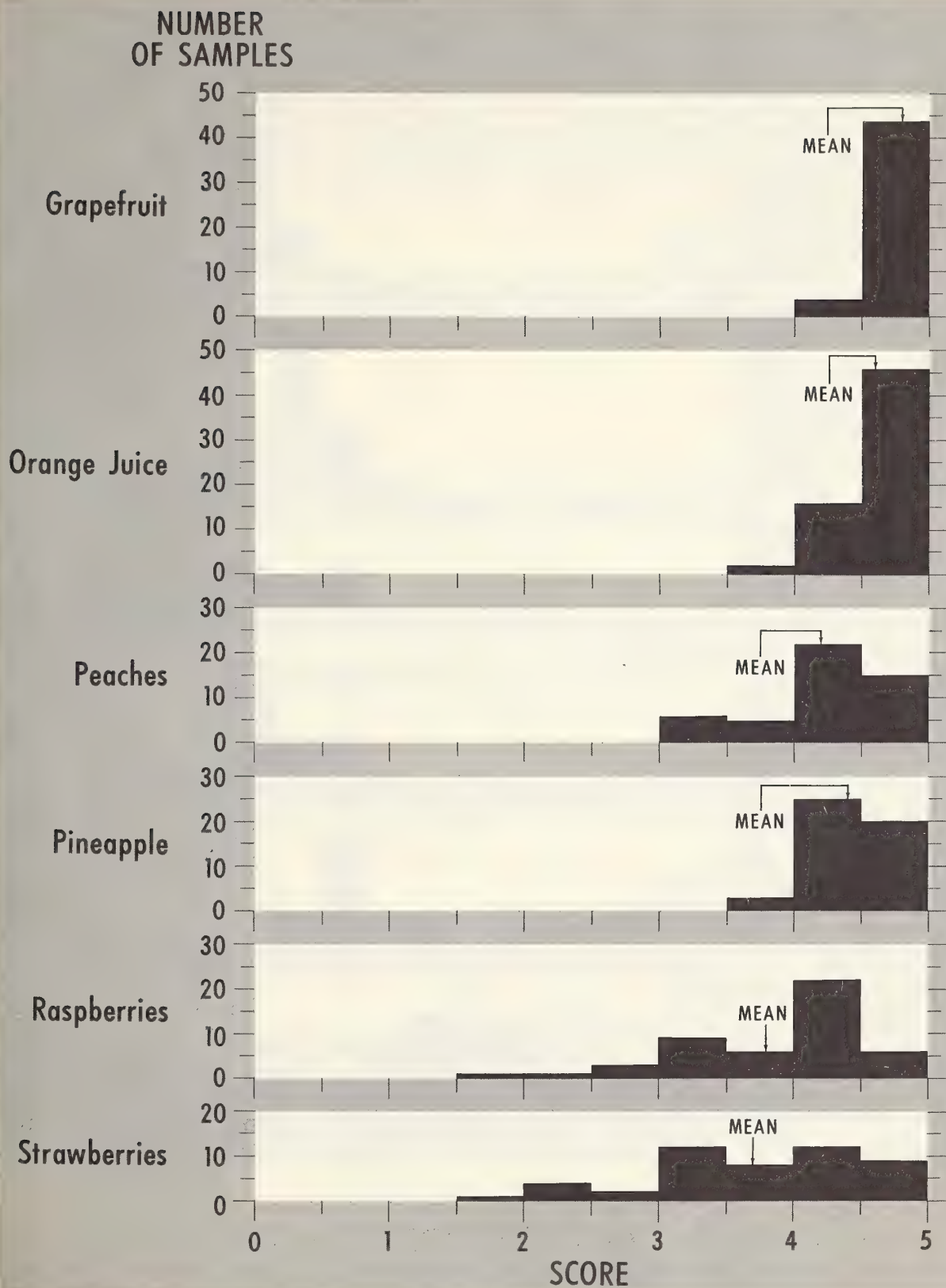


FIGURE 5.—FROZEN FRUITS: Panel color scores.

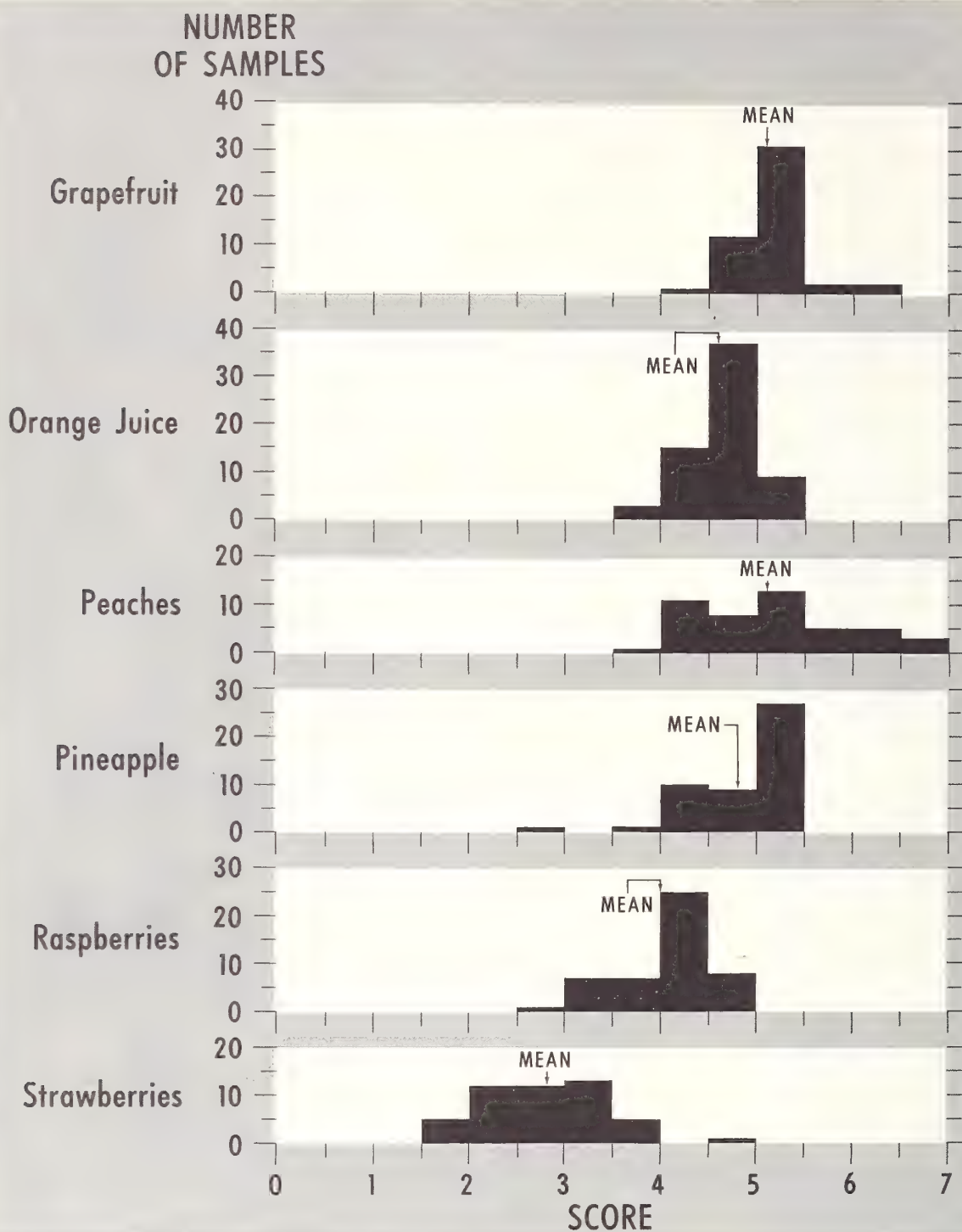


FIGURE 6.—FROZEN FRUITS: Panel texture scores.

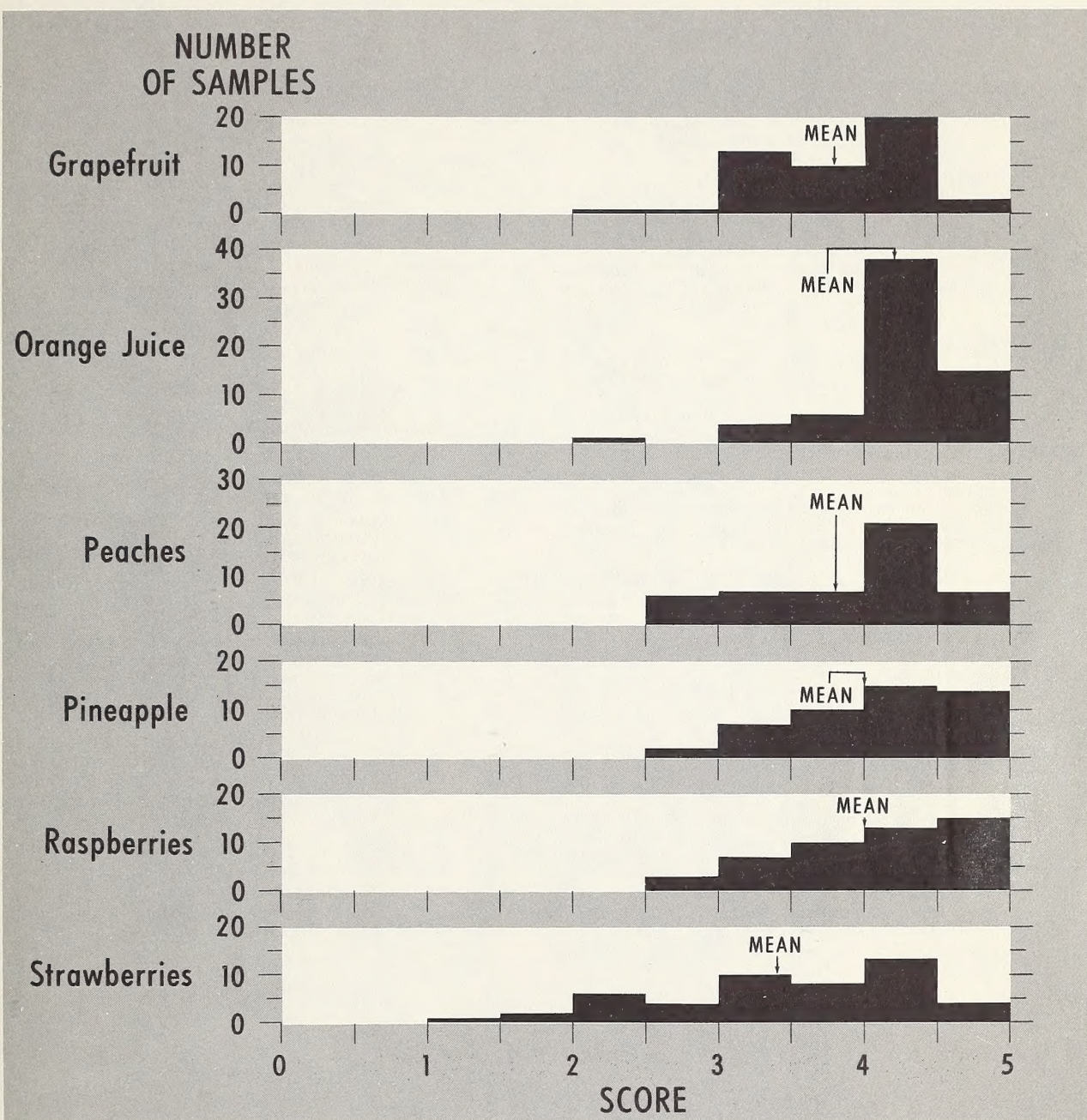


FIGURE 7.—FROZEN FRUITS: Panel flavor scores.

LITERATURE CITED

- (1) ABBE-3L REFERENCE MANUAL CAT. No. 33:45-58
[n.d.] Bausch & Lomb Optical Co., Rochester 2, N.Y.
- (2) BESSEY, O. A., and KING, C. G.
1933. THE DISTRIBUTION OF VITAMIN C IN PLANT AND ANIMAL TISSUES, AND ITS DETERMINATION. *Jour. Biol. Chem.* 103: 687-698.
- (3) BURGER, M., HEIN, L. W., TEPLY, L. J., and others.
1956. VITAMIN, MINERAL, AND PROXIMATE COMPOSITION OF FROZEN FRUITS, JUICES, AND VEGETABLES. *Jour. Agr. Food Chem.* 4: 418-425.
- (4) COCHRAN, W. G., and COX, G. M.
1957. EXPERIMENTAL DESIGNS. 2d ed. John Wiley and Sons, Inc., New York.
- (5) DERSE, P. H., and TEPLY, L. J.
1958. FROZEN FOOD STORAGE EFFECTS—EFFECTS OF STORAGE CONDITIONS ON NUTRIENTS IN FROZEN GREEN BEANS, PEAS, ORANGE JUICE, AND STRAWBERRIES. *Jour. Agr. Food Chem.* 6: 309-311.
- (6) DYKSTRA, K. G.
1952. DISTRIBUTION PRACTICES IN THE FROZEN FOOD INDUSTRY. *Canner* 114: 16, 18-19.
- (7) GARDNER LABORATORY.
[n.d.] GARDNER AUTOMATIC COLOR-DIFFERENCE METER INSTRUCTIONAL BOOKLET. Gardner Laboratory Bul. 156, 6 pp. Bethesda, Md.
- (8) GUADAGNI, D. G., NIMMO, C. C., and JANSEN, E. F.
1957. TIME-TEMPERATURE TOLERANCE OF FROZEN FOODS. VI. RETAIL PACKS OF FROZEN STRAWBERRIES. *Food Technol.* 11: 389-397.
- (9) ———, NIMMO, C. C., and JANSEN, E. F.
1957. TIME-TEMPERATURE TOLERANCE OF FROZEN FOODS. X. RETAIL PACKS OF FROZEN RED RASPBERRIES. *Food Technol.* 11: 633-637.
- (10) KELSEY, R. J.
1956. FROZEN QUALITY—HOW PROTECT IT? *Food Engr.* 28: 50-51, 96-99.
- (11) KOLMER, L., and GARTNER, J.
1961. TIME AND MONEY ECONOMIES FOR SELECTED FOODS IN VARIOUS STAGES OF PREPARATION. *Cons. Market. Bul.* IV., Iowa State Univ. Ext. Serv., 22 pp., illus.
- (12) KRAMER, A., BURKHARDT, G. J., and ROGERS, H. P.
1951. THE SHEAR PRESS: A DEVICE FOR MEASURING FOOD QUALITY. *Canner* 112: 34-35.
- (13) LAMDEN, M. P., SCHWEIKER, C. E., and PIERCE, H. B.
1960. ASCORBIC ACID STUDIES ON CHILLED, FRESH AND FERMENTED ORANGE JUICE. *Food Res.* 25: 197-202.
- (14) LEVINE, D. B.
1958. CONSUMERS APPRAISE CANNED AND FROZEN FOODS, THEIR PACKAGES AND LABELS. U.S. Dept. Agr. Market. Res. Rpt. 270, 77 pp., illus.
- (15) MCCOLLOCH, R. J., and RICE, R. G.
1955. PROPERTIES OF STORED FROZEN ORANGE CONCENTRATE OBSERVED BY DIFFERENTIAL CLOUD DETERMINATION. *Food Technol.* 9: 70-73.
- (16) MAPSON, L. W.
1942. VITAMIN METHODS-5—A NOTE ON THE DETERMINATION OF ASCORBIC ACID IN FRUITS AND VEGETABLES IN THE PRESENCE OF SO₂. *Biochem. Jour.* 26: 196-202.
- (17) MORIN, E. J.
1952. WHAT HAPPENS TO FROZEN FOODS: RETAIL PRACTICES. *Quick Frozen Foods* 14: 65-67.
- (18) MUNTER, A. M., BYRNE, C. H., and DYKSTRA, K. G.
1953. A SURVEY OF TIMES AND TEMPERATURES IN THE TRANSPORTATION, STORAGE AND DISTRIBUTION OF FROZEN FOOD. *Food Technol.* 7: 356-359.
- (19) NATIONAL ASSOCIATION OF FROZEN FOOD PACKERS.
1961. FROZEN FOOD PACKER STATISTICS, APRIL. WASHINGTON, D.C.
- (20) ROBINSON, W. B., and STOTZ, E.
1945. THE INDOPHENOL-XYLENE EXTRACTION METHOD FOR ASCORBIC ACID AND MODIFICATIONS FOR INTERFERING SUBSTANCES. *Jour. Biol. Chem.* 160: 217-225.
- (21) ROE, J. H., MILLS, M. B., OSTERLING, M. J., and DAMRON, C. M.
1948. DETERMINATION OF DIKETO-1-GULONIC ACID DEHYDRO-1-ASCORBIC ACID AND 1-ASCORBIC ACID IN THE SAME TISSUE EXTRACT BY THE 2,4-DINITROPHENYLHYDRAZINE METHOD. *Jour. Biol. Chem.* 174: 201-208.
- (22) SWEENEY, J. P., CHAPMAN, V. J., MARTIN, M. E., and DAWSON, E. H.
1961. QUALITY OF FROZEN VEGETABLES PURCHASED IN SELECTED RETAIL MARKETS. *Food Technol.* 15: 341-345.
- (23) ———, CHAPMAN, V. J., MARTIN, M. E., and others.
1962. VEGETABLES—CONSUMER QUALITY, YIELD, AND PREPARATION TIME OF VARIOUS MARKET FORMS. U.S. Dept. Agr. Home Econ. Res. Rpt. 17, 17 pp.

